STATE OF ILLINOIS
WILLIAM G. STRATTON, *Governor*
DEPARTMENT OF REGISTRATION AND EDUCATION
VERA M. BINKS, *Director*

Influence of Coking Time on Expansion Pressure and Coke Quality

H. W. Jackman
R. L. Eissler
R. J. Helfinstine

DIVISION OF THE
ILLINOIS STATE GEOLOGICAL SURVEY
JOHN C. FRYE, *Chief* URBANA

CIRCULAR 246 1958

INFLUENCE OF COKING TIME ON EXPANSION PRESSURE AND COKE QUALITY

H. W. Jackman, R. L. Eissler, and R. J. Helfinstine

ABSTRACT

Pilot-plant coking tests on coal blends have shown that expansion pressure of coke against the oven wall varies with coking time, but not always in a predictable manner. We concluded that when coals are to be judged on the basis of these tests, they should be made at the rate of coking to be used commercially. A standard test oven, and standard operating procedures, should be developed if expansion pressures determined in different laboratories are to be compared.

As is well known, physical properties of coke vary with the rate of coking; this report shows trends over the wide range studied.

INTRODUCTION

The expansion pressure developed against the wall of a laboratory test oven by any blend of coals is an empirical value that may vary according to the design of the test oven or according to operating procedures used in the test. Just how much this pressure may vary for any specific coal blend can be determined only by experimentation. With some coals it has been shown to be appreciable.

It is common knowledge that the pressure developed in a coke oven depends on the bulk density of the coal in the oven. Loosely packed coal tends to develop low pressure during carbonization. Conversely, an expanding coal blend charged at a high bulk density may produce damaging pressures on the walls of an oven, and for this reason bulk density generally is controlled in plant operation, either by maintaining coal pulverization within narrow limits, or by addition of moisture or oil to the coal. In order to determine the maximum pressure that might develop in commercial ovens, coal samples for expansion tests are commonly air dried so that tests may be made at the greatest bulk density that might prevail in any portion of a commercial coke oven.

Other operating procedures also affect the pressure imposed on oven walls. Among these is the rate at which coal is carbonized, or, in the common terminology, the coking time. Russell (1949) reports a definite reduction in pressure as the flue temperature of the 12-inch oven is reduced and the coking time lengthened. Others have reported that variations in the rate of coking have an indefinite effect on expansion pressure, in some cases causing it to decrease and in some cases to increase (British Coke Research Assn., 1952).

In view of this somewhat conflicting evidence, the Illinois State Geological Survey has tested coal blends over a wide range of coking times in its movable-wall coke oven. This oven (fig. 1) is 17 inches wide and has a capacity of 675 pounds of coal (Jackman, 1955). When operating the oven under temperature conditions simulating those of commercial ovens, we determine the expansion pressure of the blend and obtain a coke that closely duplicates the commercial product in physical and chemical properties.

There were two practical reasons for this investigation. First, we had found, as did Russell, that certain coal blends expanded strongly when tested

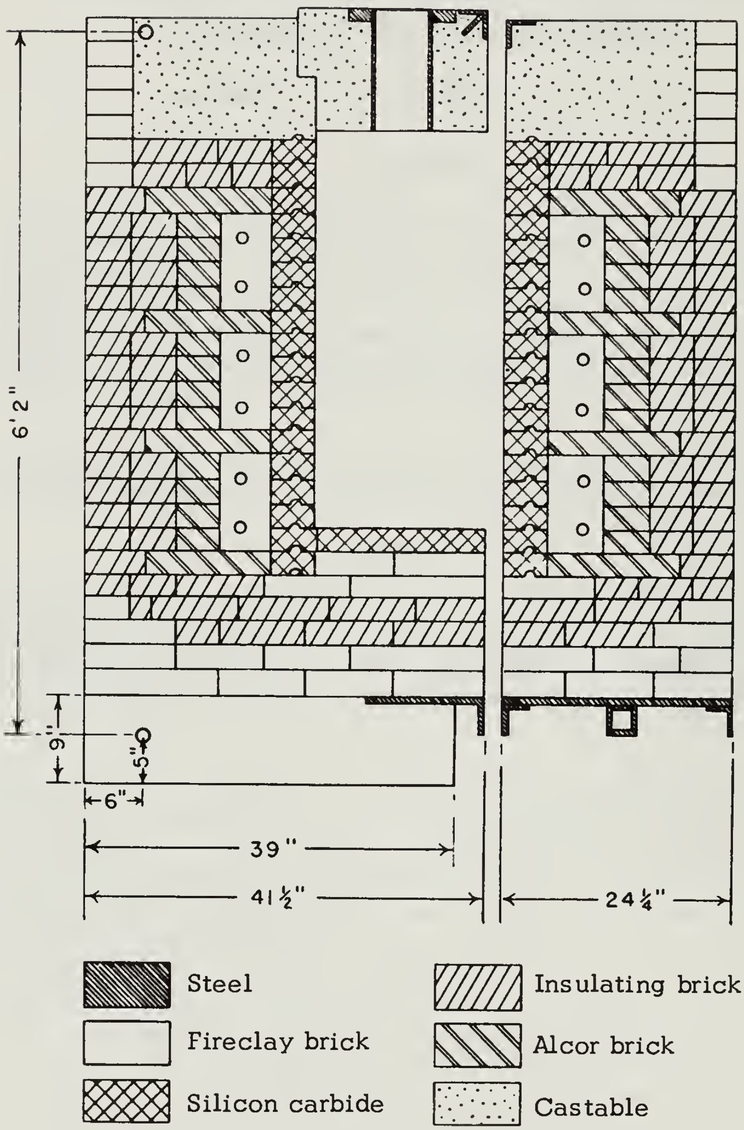

Fig. 1. - Cross section of oven through brickwork.

under usual laboratory procedures, but developed lower pressures when coked slowly, as for the production of foundry coke. We wished to determine whether this relationship is true of blends in general, or whether with certain blends the pressure may remain constant or increase at slower rates of coking, as noted in the British source cited. Also, knowing that coking time does affect the expansion pressure, we wished to show the need for standardizing test procedure in the operation of movable-wall ovens when comparisons of tests run in different laboratories are made, or when coals are to be accepted or rejected on the basis of a maximum pressure value such as the well known limit of two pounds per square inch.

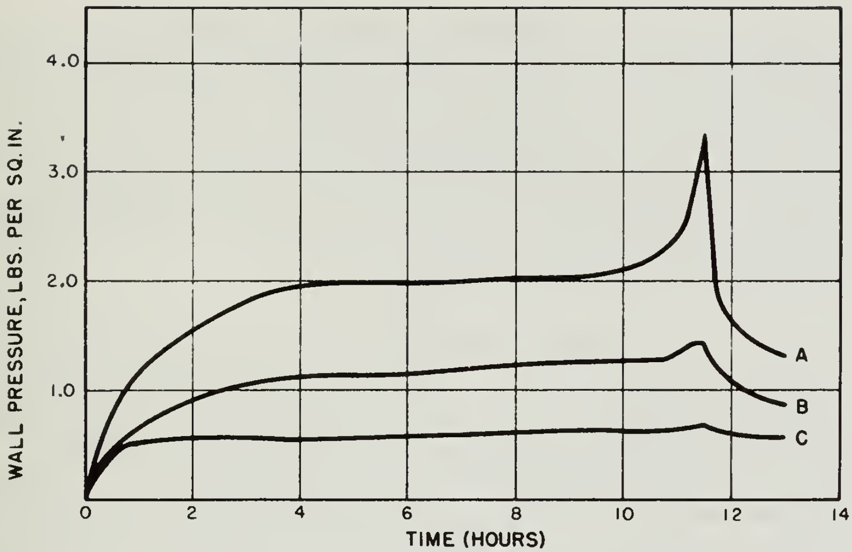

Fig. 2. - Representative pressure curves.

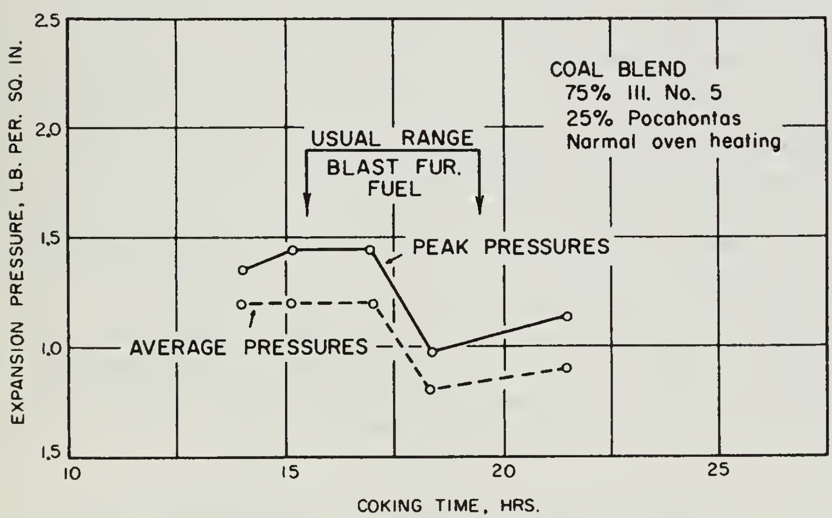

Fig. 3. - Expansion pressure vs. coking time.

The coals used in this investigation were obtained from both the Illinois and Appalachian fields. We wish to thank both the coal and steel companies in the Illinois-Indiana area that furnished certain of these coals, and the coal producers in Illinois and Virginia who furnished coals directly from the mines.

PROCEDURE

Tests on a number of coal blends, including those that develop very low pressure with practically no pressure peak, those that develop a dangerously high pressure peak, and the more normal, average type of blend are described. Blends thought to be suitable for both blast furnace coke and foundry coke were tested.

The 17-inch width of the experimental coke oven is equal to the average width of a commercial oven, so that the experimental rates of coking correspond directly with those of full size ovens. Coking times for individual blends were varied from a 12-hour minimum to a 28-hour maximum. The usual rate, however, was from 14 to 24 hours. Maximum and average expansion pressures over this range were noted and have been plotted to show trends. In addition, the physical properties and yields of coke were determined for each experimental oven test. These data on coke quality have been plotted to show general trends resulting from the variation in coking time.

EXPERIMENTAL RESULTS

Pressures in the experimental oven, recorded from the time coal is charged until after a pressure peak has been registered, tend to follow one of the curves shown in figure 2. Curve A represents the pressure produced during coking of a blend having fairly high expansion properties. Pressure generally increases rapidly for about four hours with blends of this type. After a period of gradual increase, a rapid rise in pressure occurs as the plastic zones meet. This is followed by a sudden pressure drop when the plastic envelope breaks, releasing trapped gases.

Curve B represents the pressure conditions when a blend with fairly low expansion properties, such as a mixture of Illinois coals with Pocahontas, is coked. Curve C depicts the extreme condition occurring when gases are not entrapped by the plastic envelope in sufficient quantity to produce a definite peak. Variations in curve C may occur in which a maximum pressure is reached within the first four hours, and is followed by a gradual pressure drop. In this case a final peak may or may not develop.

For the purpose of discussion we have divided the blends studied here into two general groups: first, that in which the chief high-volatile constituent is Illinois coal, and second that group in which the high-volatile coal comes chiefly from the eastern coal fields.

The analyses and plastic properties of all coals used in blends are shown in table 1, and the expansion pressures, both maximum and average, for both groups of blends are shown in tables 2 and 3. Analyses of blends and the cokes produced are shown in table A of the appendix.

Table 1. - Analyses and Plastic Properties of Individual Coals

	Analyses					
		Moisture-free basis				
Coal	M.	V.M.	F.C.	Ash	Sulfur	F.S.I.
Illinois No. 5	6.6	37.0	55.4	7.6	1.30	6
Illinois No. 6	9.1	38.0	54.3	7.7	1.01	5
Kentucky Elkhorn	5.0	38.2	57.5	4.3	0.99	$5\frac{1}{2}$
West Virginia Eagle	5.4	29.5	64.8	5.7	0.66	9
Virginia medium-volatile	3.1	21.3	73.3	5.4	0.58	9
Pocahontas	4.0	17.0	75.9	7.1	0.87	9

Table 1. - Continued

Coal	Plastic Properties: Gieseler Fluidity Dial div. per min.	Plastic Range °C.
Illinois No. 5	58	77
Illinois No. 6	37	75
Kentucky Elkhorn	144	65
West Virginia Eagle	3,000	100
Virginia medium-volatile	1,020	92
Pocahontas	10	61

Group I - Illinois Coal Blends

Illinois No. 5 Coal Blended with Pocahontas

The first blend studied contained 75 percent Illinois No. 5 and 25 percent Pocahontas coals. This blend has a relatively low expansion pressure regardless of the rate at which it is coked. In this study the blend was carbonized at a range of flue temperatures that caused complete coking in 14:00, 15:10, 17:00, 18:20, and 21:00 hours, respectively. Maximum and average wall pressures are plotted in figure 3.

At what might be considered the usual coking time range for producing blast furnace fuel in a 17-inch oven, $15\frac{1}{2}$ hours to $19\frac{1}{2}$ hours, the maximum expansion pressure for this blend was shown to range between approximately 1.45 and 1.0 pounds per square inch. Greatest pressures were recorded for coking times of 15 and 17 hours, and the pressure decreased during longer coking times. It was noted also that at the extremely fast coking time of 14 hours a lower pressure was exerted, probably because of the greater shrinkage and cracking of the coke structure taking place at this rapid rate of heating.

To check this blend of coals further, a second series of coking tests was made with somewhat faster heat input to the coal at the start of each run. This procedure simulated the effect of charging coal into unusually hot ovens. A maximum pressure curve of the same general shape as before was obtained, but with slightly lower values (fig. 4). The greatest expansion pressure obtainable was 1.31 pounds per square inch. Pressures ranged from 1.25 to 0.95 pounds in the usual coking range.

Illinois Coals Blended with Medium-Volatile Coal

Next to be studied were two blends, one of 50 percent Illinois No. 5 coal and 50 percent medium-volatile coal from Virginia, and the other of 50 percent Illinois No. 6 coal and 50 percent of the same Virginia coal. The medium-volatile coal (21 percent V.M.) had a relatively high Gieseler fluidity, and like similar coals tended to exert less pressure during carbonization than the less volatile Pocahontas coals.

The blend of this Virginia coal with the Illinois No. 5 produced an exceptionally strong coke, but under no conditions was a wall pressure as high as 1.1 pounds per square inch obtained. In the usual coking range the maximum

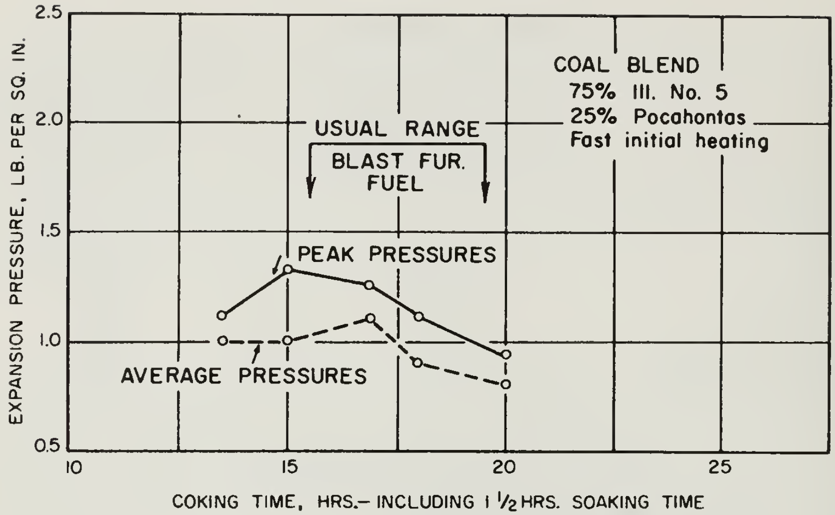

Fig. 4. - Expansion pressure vs. coking time.

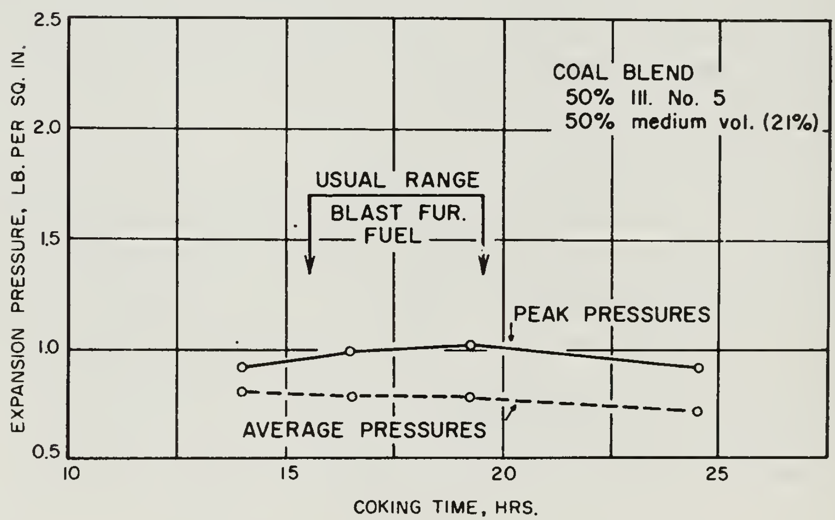

Fig. 5. - Expansion pressure vs. coking time.

wall pressure varied from about 0.95 to 1.02 pounds, with slightly lower pressures at the extremely fast and slow coking rates. These values probably all lie within the range of reproducibility. The average pressures throughout the range of coking time were practically constant (fig. 5).

Illinois No. 6 coal blended with medium-volatile Virginia coal also produced strong coke and exerted uniformly low expansion pressures, only a little higher than those of the previous series. Here, however, a small increase in peak pressure was noted at the $24\frac{1}{2}$-hour coking rate. The average pressure curve (fig. 6) shows that, although the peak pressure increased at this slow rate of coking, the average pressure decreased slightly.

The results of both these series indicated that Illinois coals may be blended with up to 50 percent of this medium-volatile Virginia coal and coked without

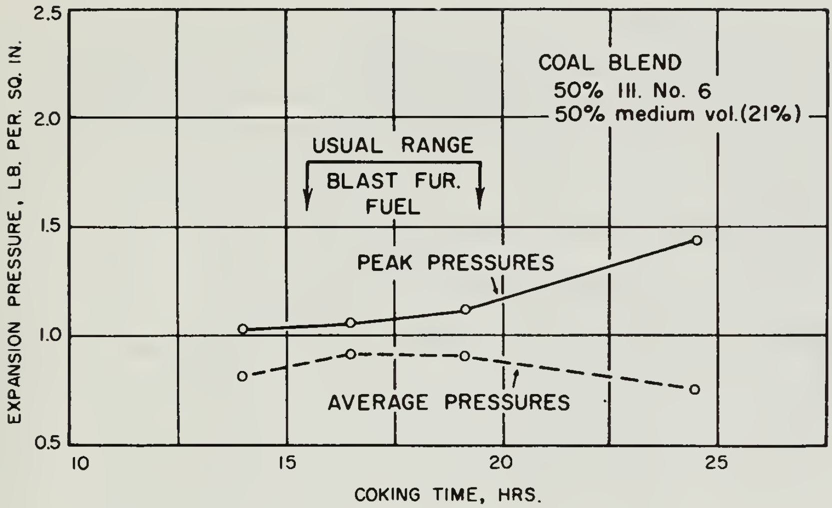

Fig. 6. - Expansion pressure vs. coking time.

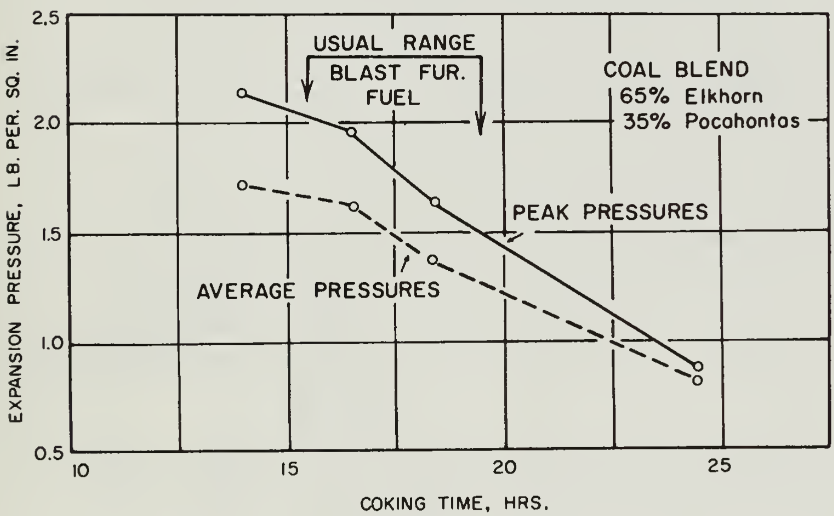

Fig. 7. - Expansion pressure vs. coking time.

producing wall pressures commonly considered to be unsafe. Moreover, the coking time may be varied over a wide range, from the fast rates usual for producing blast furnace fuel to the slow rates necessary to produce large size foundry coke, without appreciably affecting the pressure on oven walls.

Group 2 - Eastern Coal Blends

Kentucky Elkhorn Blended with Pocahontas

Elkhorn coal was blended with Pocahontas in the proportions 65 Elkhorn, 35 Pocahontas and coked at temperatures that caused complete carbonization in 14:00, 16:30, 18:20, 24:30, and 28:00 hour periods. The wall pressure exerted

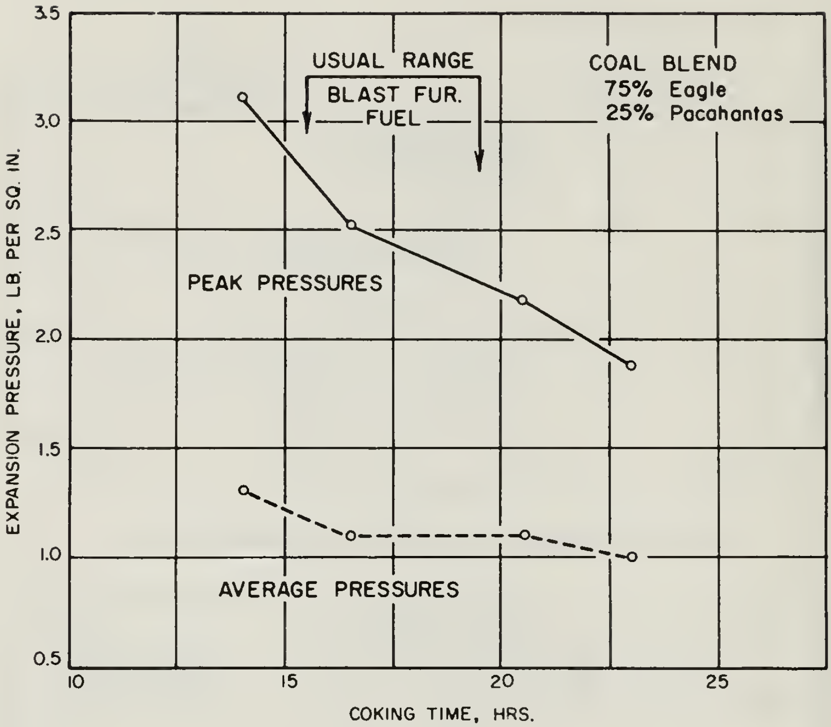

Fig. 8. - Expansion pressure vs. coking time.

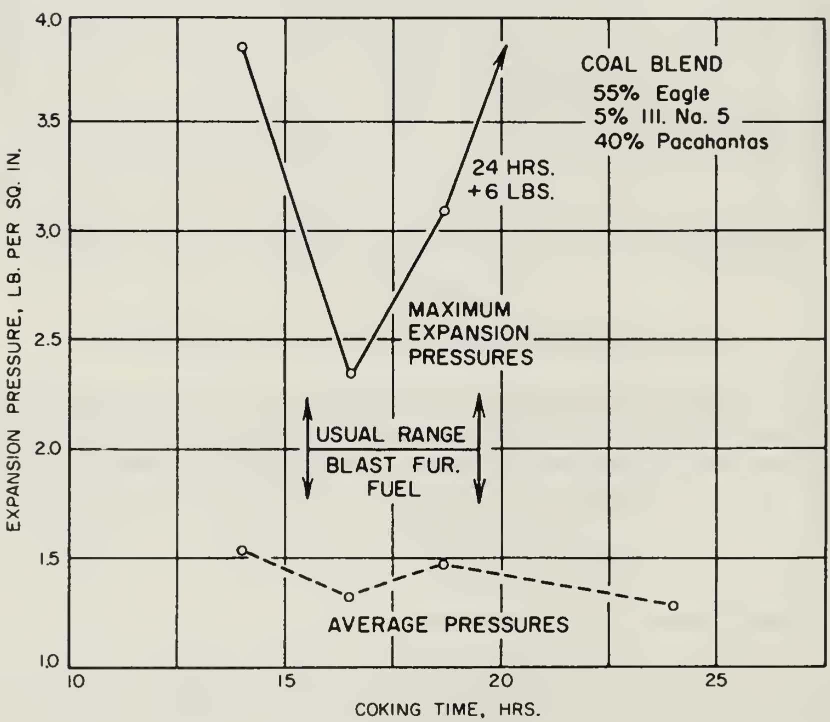

Fig. 9. - Expansion pressure vs. coking time.

by this blend was found to be very dependent on the rate of heating, dropping consistently with increase in coking time from a high of 2.13 pounds per square inch at the fastest rate to 0.9 pound at 24:30 hours (fig. 7). At coking times usual for producing blast furnace coke, the pressure fell from about 2.05 pounds at $15\frac{1}{2}$ hours to 1.5 pounds at $19\frac{1}{2}$ hours. The average pressure throughout the coking period also dropped consistently as the coking time was lengthened.

Examination of the cell structure of the full-length pieces of coke (one-half the oven width) showed the inner ends (about 1/2 to 1 inch) tended to develop a softer, punkier structure as coking time was increased. Therefore, it is assumed that the plastic envelope containing the gases contributing to peak pressure becomes more porous at the slower rates of heating and allows easier exit for gas and less build-up of pressure at the time the plastic zones meet. With this type of coke structure we believe it is desirable to determine expansion pressure at the coking rate to be used in commercial practice if the results are to correlate with expected pressures on commercial oven walls.

West Virginia Eagle Blended with Pocahontas

A blend of 75 percent Eagle seam and 25 percent Pocahontas coals was coked at four rates - 14:00, 16:30, 20:30 and 23:00 hours. The Eagle coal develops a high Gieseler fluidity, has a high free-swelling index, and produces strong coke in a blend such as this. At 14 hours coking time a high peak pressure of 3.1 pounds per square inch was exerted against the oven wall. At $16\frac{1}{2}$ hours the pressure had dropped to 2.5 pounds, and continued to fall until, at 23 hours, it was less than 1.9 pounds (fig. 8). The average pressure during the coking cycle remained fairly constant throughout the range of coking time, indicating that only the peak pressure showed much variation with rate of coking. The coke structure, upon examination, did not indicate a reason for peak pressure variation as did the coke structure of the previous series. However, as in the case of the Elkhorn blend, it appears that expansion pressures should be determined at the commercial rate of coking if results are to be applied to commercial practice.

A second blend of these two coals in which the Pocahontas coal was increased to 40 percent to produce a typical foundry coke was tested. Preliminary tests at $16\frac{1}{2}$ hours produced an expansion pressure of more than 6 pounds per square inch. (The maximum capacity of our pressure gauges is six pounds.) It was found by trial that if 5 percent of Illinois No. 5 coal were added, this high pressure was reduced to 2.3 pounds at the same rate of coking. The blend as finally tested, therefore, contained 55 percent Eagle, 5 percent Illinois No. 5, and 40 percent Pocahontas.

Expansion pressure results (fig. 9) show the great importance of testing for pressure at the rate at which the blend is to be coked commercially. The pressure at 14 hours coking time increased to 3.8 pounds per square inch, as might have been expected from previous experience with other blends, but instead of dropping as the coking time was lengthened beyond $16\frac{1}{2}$ hours, the pressure on the walls again increased at 18:40 hours to 3.1 pounds, and at 24 hours to more than 6 pounds.

This blend produced an excellent-appearing foundry coke at the 24-hour coking time, but a pressure was exerted on the oven walls that might have caused serious damage to a commercial oven battery. Moreover, it appears that although a blast furnace coke might be produced safely at about $16\frac{1}{2}$ hours coking

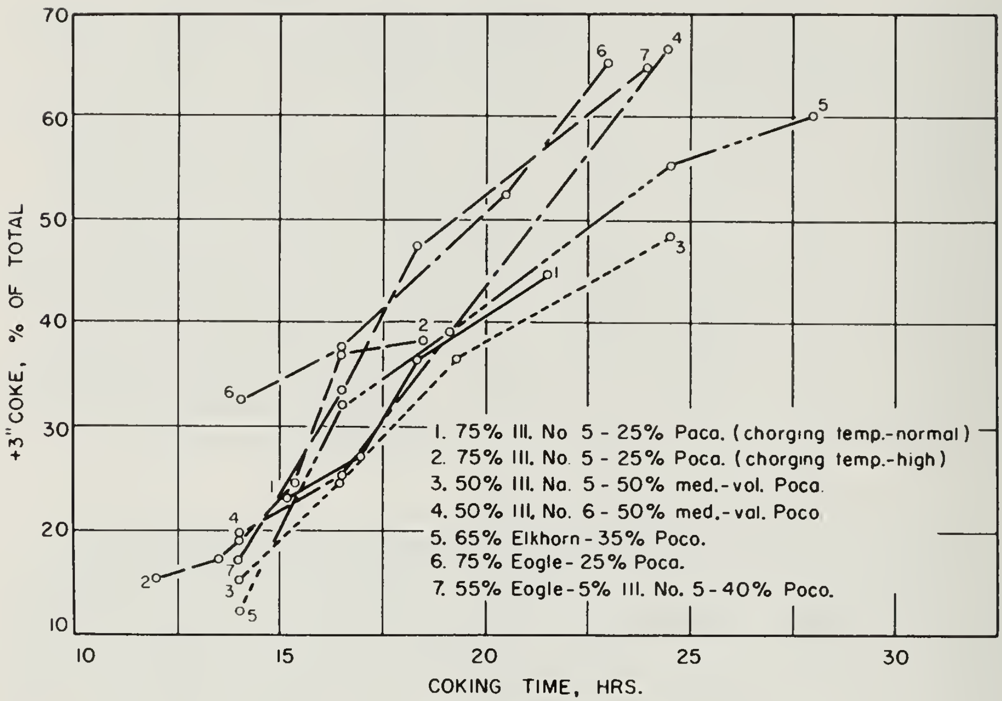

Fig. 10. - Plus 3-inch coke vs. coking time.

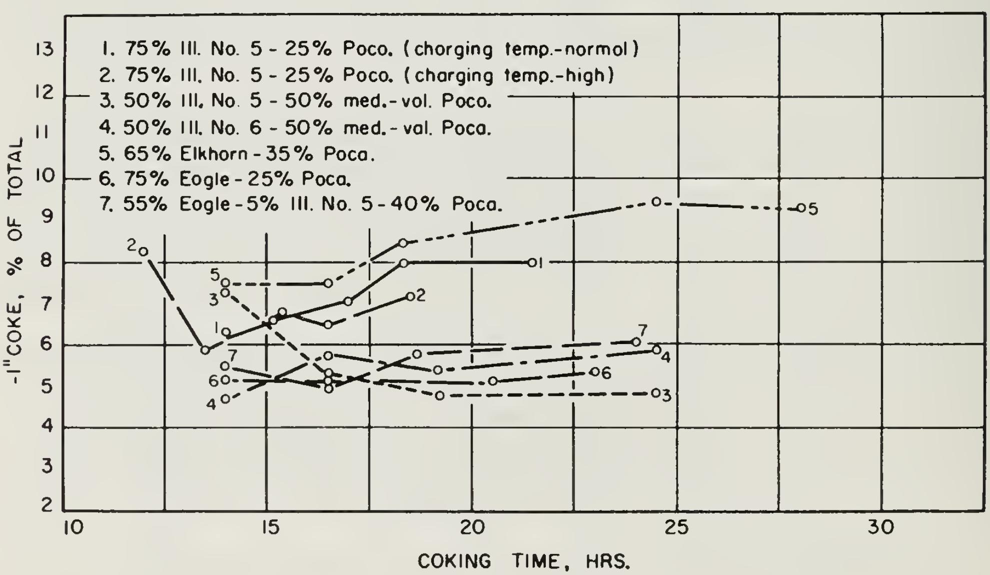

Fig. 11. - Minus 1-inch coke vs. coking time.

time, such a procedure would be hazardous due to the high wall pressures obtained at both faster and slower rates of coking.

Examination of the coke produced at the long coking time gave evidence that a very dense, hard, cell structure formed at the inner ends of the coke pieces. This peculiar structure was not much in evidence in the cokes made at faster rates, so we assume that this structure was responsible for retaining the gases inside the plastic envelope at the time of peak pressure, thereby producing the high wall pressure.

Coke Physical Properties

In addition to determination of expansion pressures on the six blends studied, determinations were made of the physical properties of each of the cokes produced. Results of these tests, along with the yields of coke, are shown in tables B to H of the Appendix. Physical properties also have been plotted in order to show more clearly the effect of the rate of coking on such coke properties as sizing and the shatter and tumbler indices. The trends shown will be discussed briefly.

Coke Sizing

Coke size, of course, increases as the coking time is lengthened. Figure 10 shows this trend for each of the blends studied, and, moreover, shows that the percentage of larger sized coke pieces (plus 3-inch) increases at a similar rate for each blend. We have computed that for each additional hour of coking time there is an increase of from 3 to 4.5 percent in the plus 3-inch size coke.

The coke fines, shown here as the minus 1-inch portion, are plotted in figure 11. The fines do not react to change in coking time as consistently as do the larger sizes. Coke fines increase at the longer coking times for blends that have a relatively low Gieseler fluidity. These include the Illinois No. 5 - Pocahontas and the Elkhorn - Pocahontas blends. Fines from the other blends, all of which have higher fluidity, are not affected greatly by coking time.

Shatter Test

The shatter indices, both 2-inch and $1\frac{1}{2}$-inch, increase consistently for each coal blend studied as the coking time is lengthened (figs. 12 and 13). Samples for the determination of shatter contain proportional amounts of each size of coke above the 2-inch level. Consequently, the samples contain increasingly larger amounts of the plus 3-inch sizes at the longer rates of coking.

Figure 14 shows the relationship between shatter and the total percentage of plus 3-inch coke produced, and indicates that for each individual blend there is a direct relationship between shatter and coke size. It is for this reason that some coke producers have discarded the shatter test, which they maintain gives no information on coke structure that is not shown equally well by the sizing of the coke.

Tumbler Test

Tumbler stability indices are plotted in figure 15. The general trend is an increase in coke stability with longer coking time. This is true especially in the range between 14 and $16\frac{1}{2}$ hours coking time, but stability continues to increase

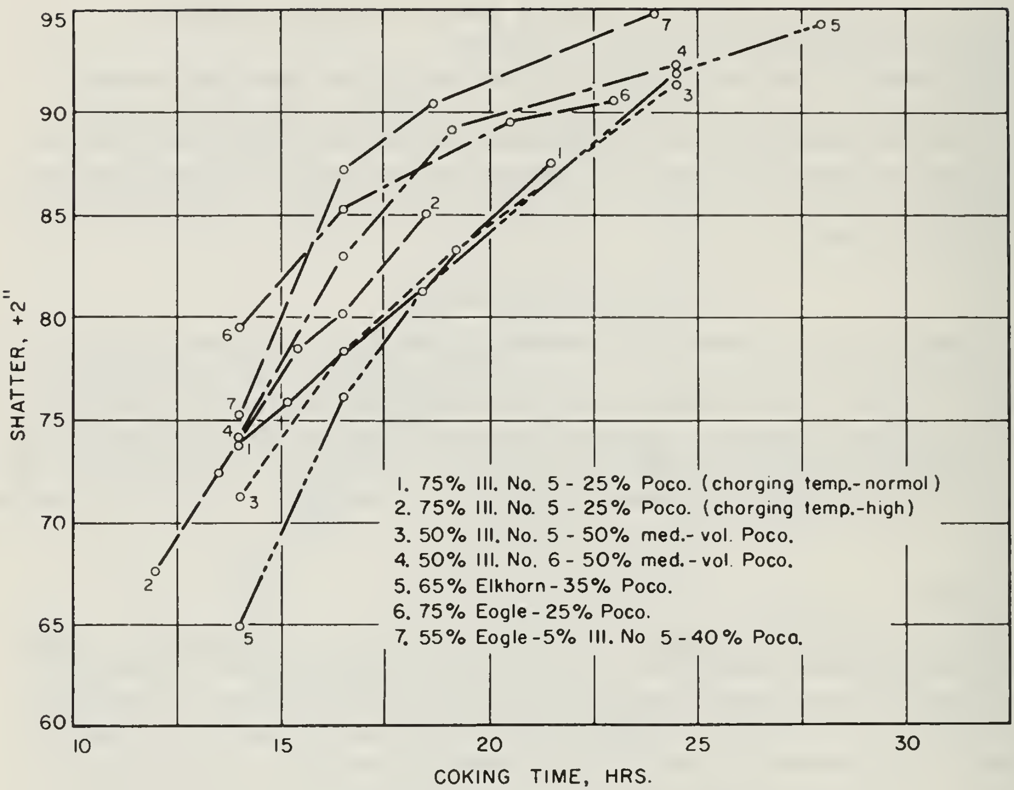

Fig. 12. - Shatter (plus 2-inch) vs. coking time.

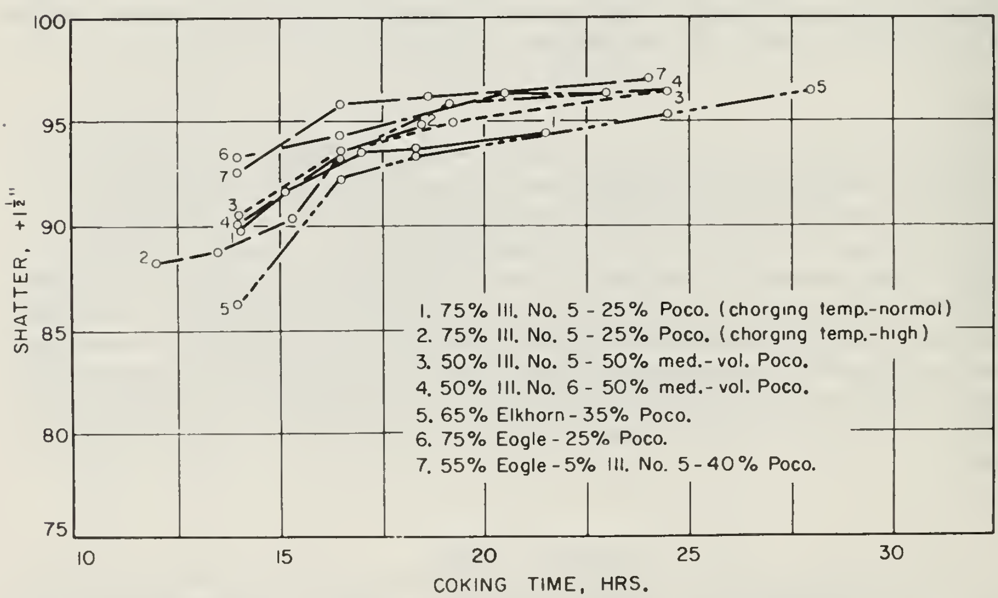

Fig. 13. - Shatter (plus 1 1/2-inch) vs. coking time.

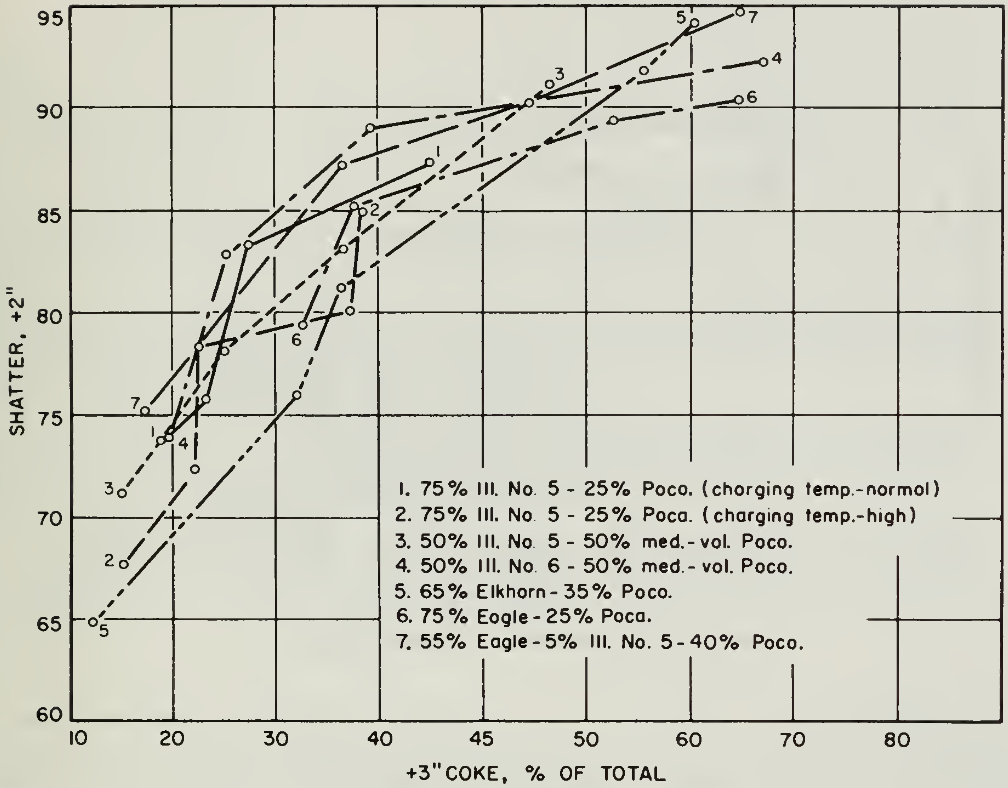

Fig. 14. - Shatter (plus 2-inch) vs. coking time.

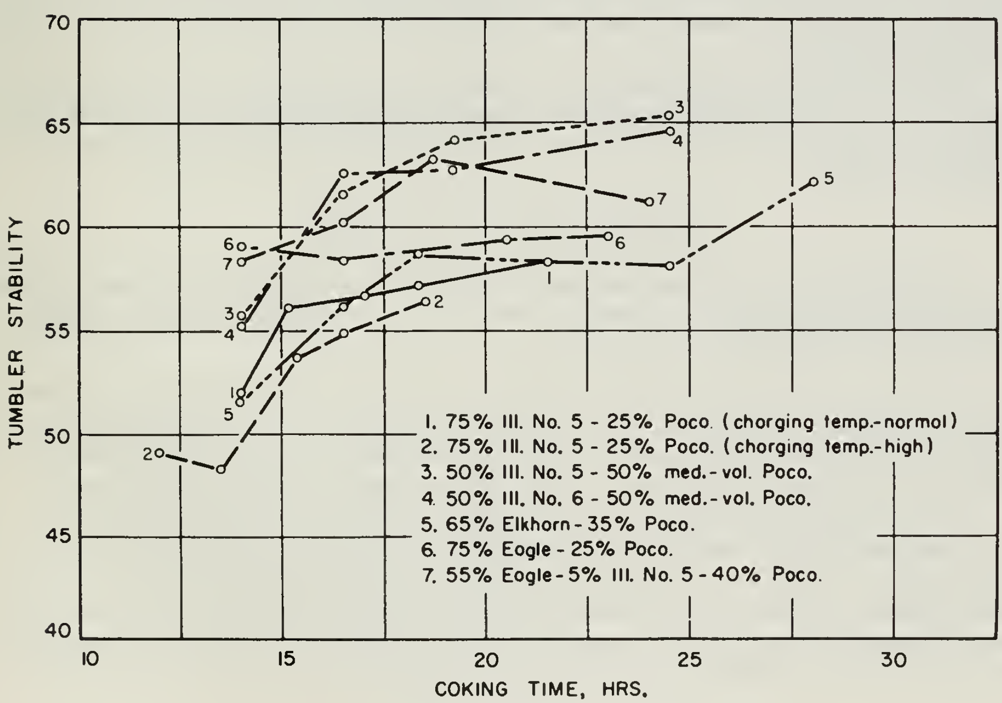

Fig. 15. - Stability vs. coking time.

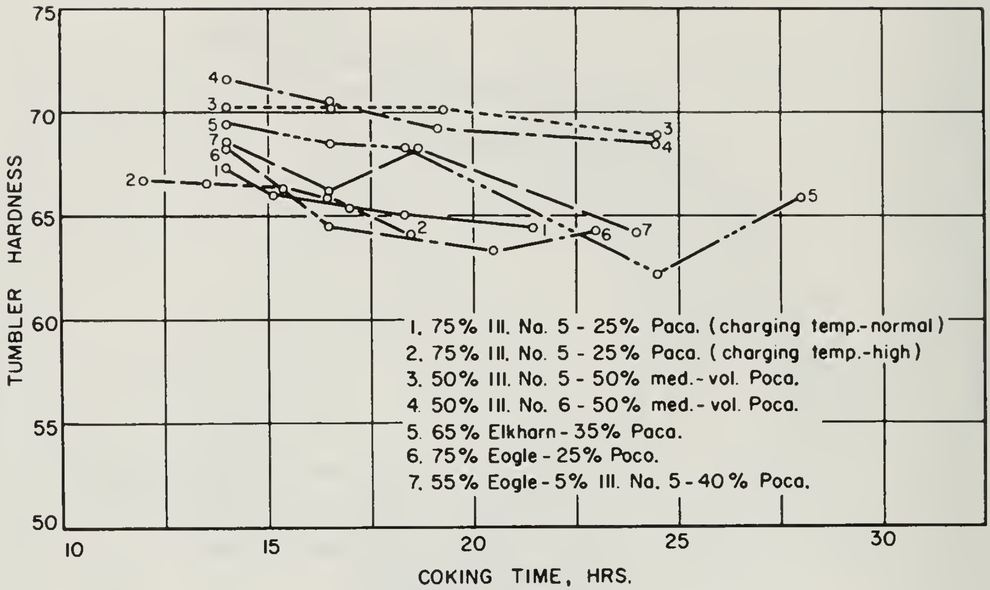

Fig. 16. - Hardness vs. coking time.

slowly throughout the entire range. The increase in stability is shown to be much less than the corresponding increase in the shatter indices. This is to be expected, as tumbler tests are made on a uniform size of coke (3 by 2 inches) and so are not affected by the over-all size range of the coke. However, fast coking, especially at the 14-hour rate, does cause greater shrinkage and more numerous cracks and stresses are set up within the coke pieces. Lower stability indices result.

Tumbler hardness indices, which are plotted in figure 16, show the opposite trend. Almost without exception, hardness decreases as the coking time is lengthened. The decrease is not great, averaging only about three points over the entire range.

SUMMARY AND CONCLUSIONS

Pilot-plant tests in the movable-wall oven, in which both expansion pressure and coke properties were determined over a wide range of coking times, have led to the following conclusions.

1. Expansion pressure varies with coking time but not always in a predictable manner. Blends that exert a high pressure at the fast coking rate required for blast furnace fuel may be safe to use when foundry coke is being produced at longer coking time. There are exceptions to this generalization.

2. Blends containing large percentages of Illinois coals developed low expansion pressures, commonly considered to be safe, at any rate of coking. When Illinois coals were blended with regular Pocahontas coal, the maximum pressure was reduced by lengthening the coking time. When the Illinois coals were blended with coal of 21 percent volatile matter, the pressure developed was practically independent of the rate of coking.

3. Blends in which the high volatile coal was principally from the Appalachian fields were less predictable. As the coking time was lengthened, maximum expansion pressures were shown to decrease consistently with two blends, but to increase dangerously with a third.

4. When coal blends are to be rejected or accepted on the basis of a maximum expansion pressure, it appears that the pressure tests should be made at the rate of coking to be used commercially.

5. If expansion pressures determined in different laboratories are to be compared, it would be desirable to develop a standard width test oven, and to standardize the operating conditions under which tests would be made. More than one set of standard operating conditions would make possible the evaluation of blends for blast furnace or foundry coke.

6. Sizing tests on coke show that for each blend tested the size of the coke pieces increases consistently as the coking time is lengthened. The shatter indices for any specific coal blend also are shown to increase consistently with the size of the coke pieces.

7. Tumbler stability also tends to increase as the coking time is lengthened, particularly at the faster rates of coking. Changes in stability at coking times longer than 17 or 18 hours tend to be minor. Tumbler hardness indices, almost without exception, are lowered by a longer coking time.

Table 2. - Expansion Pressure vs. Coking Time

Illinois Coal Blends

Coking time Hours	Maximum expansion pressure Lb. per sq. in.	Average pressure (1st hour to maximum) Lb. per sq. in.	Bulk density Lb. per cu. ft.
	75% Illinois No. 5, 25% Pocahontas (normal oven heating)		
14:00	1.37	1.2	51.1
15:10	1.45	1.2	51.1
17:00	1.46	1.2	51.1
18:20	0.97	0.8	51.1
21:00	1.14	0.9	51.1
	75% Illinois No. 5, 25% Pocahontas (fast initial heating)		
12:00	1.11	1.0	51.1
13:30	1.33	1.0	50.9
15:20	1.26	1.1	51.1
16:30	1.11	0.9	51.1
18:30	0.95	0.8	51.1
	50% Illinois No. 5, 50% Virginia medium-volatile		
14:00	0.90	0.8	52.8
16:30	0.99	0.8	52.9
19:15	1.02	0.8	52.9
24:30	0.91	0.7	52.8
	50% Illinois No. 6, 50% Virginia medium-volatile		
14:00	1.02	0.8	52.3
16:30	1.06	0.9	52.3
19:10	1.12	0.9	52.3
24:30	1.44	0.75	52.3

Table 3. - Expansion Pressure vs. Coking Time

Eastern Coal Blends

Coking time Hours	Maximum expansion pressure Lb. per sq. in.	Average pressure (1st hour to maximum) Lb. per sq. in.	Bulk Density Lb. per cu. ft.
	65% Kentucky Elkhorn 35% Pocahontas		
14:00	2.14	1.7	55.4
16:30	1.97	1.6	55.4
18:20	1.44	1.4	54.7
24:30	0.89	0.8	55.0
28:00	0.98	1.0	55.0
	75% West Virginia Eagle 25% Pocahontas		
14:00	3.10	1.3	51.9
16:30	2.52	1.1	51.9
20:30	2.18	1.1	51.9
23:00	1.88	1.0	52.3
	55% West Virginia Eagle 5% Illinois No. 5 40% Pocahontas		
14:00	3.84	1.5	53.1
16:30	2.24	1.3	53.1
18:40	3.09	1.45	53.5
24:00	+6.00	1.25	53.5

REFERENCES

British Coke Research Assn., 1952, Swelling pressures in a coke oven: Blast Furnace and Steel Plant, v. 40, p. 1319.

Jackman, H. W., Helfinstine, R. J., Eissler, R. L., and Reed, F. H., 1955, Coke oven to measure expansion pressure - modified Illinois oven: Illinois Geol. Survey Reprint Series 1955-E.

Russell, C. C., Perch, Michael, and Farnsworth, J. F., 1949, Reducing coal-expansion pressure: Blast Furnace, Coke Oven and Raw Mat. Proc., AIME, v.8, p.32-47.

APPENDIX

Analytical and Coking Results

Table A. - Analyses of Coal Blends and Cokes

	Run No.	Coking time Hr.:min.	M.	Moisture-free analysis V.M.	F.C.	Ash	Sulfur	Max. fluidity Dial div. per min.
		75% Illinois No. 5 / 25% Pocahontas (normal heating)						
Coal blend			5.1	32.0	60.9	7.1	1.22	10
Cokes	210E	14:00		2.0	87.9	10.1	0.99	
	215E	15:10		1.4	89.1	9.5	0.98	
	206E	17:00		1.5	88.8	9.7	0.91	
	219E) 231E)	18:20		1.6	88.4	10.0	0.96	
	207E	21:00		1.6	88.7	9.7	0.94	
		75% Illinois No. 5 / 25% Pocahontas (fast initial heating)						
Coal blend			5.2	32.1	60.7	7.2	1.24	11
Cokes	213E	12:00		1.4	88.9	9.7	0.93	
	220E) 230E)	13:30		1.7	88.3	10.0	0.97	
	208E	15:20		1.0	89.2	9.8	0.91	
	216E	16:30		1.8	89.1	9.1	1.00	
	214E	18:30		2.1	88.7	9.2	0.96	
		50% Illinois No. 5 / 50% Virginia medium-volatile						
Coal blend			3.1	29.4	64.0	6.6	1.45	122
Cokes	276E	14:00		1.0	90.1	8.9	1.13	
	274E	16:30		1.1	90.0	8.9	1.07	
	275E	19:15		1.5	89.7	8.8	1.14	
	273E	24:30		1.4	89.5	9.1	1.16	
		50% Illinois No. 6 / 50% Virginia medium-volatile						
Coal blend			4.0	29.9	63.7	6.4	0.82	28
Cokes	270E	14:00		1.3	90.0	8.7	0.63	
	271E	16:30		1.0	90.4	8.6	0.64	
	269E	19:10		1.5	89.9	8.6	0.66	
	268E	24:30		1.8	89.5	8.7	0.65	

Table A. - Continued

	Run No.	Coking time Hr.:min.	M.	Moisture-free analysis V.M.	F.C.	Ash	Sulfur	Max. fluidity Dial div. per min.
			65% Kentucky Elkhorn 35% Pocahontas					
Coal blend			1.9	30.4	64.5	5.1	0.87	16
Cokes	257E	14:00		1.2	91.9	6.9	0.74	
	256E	16:30		1.3	91.6	7.1	0.79	
	258E	18:20		1.6	91.2	7.2	0.80	
	255E	24:30		1.7	91.3	7.0	0.78	
	254E	28:00		1.9	91.1	7.0	0.76	
			75% West Virginia Eagle 25% Pocahontas					
Coal blend			1.8	26.5	67.4	6.1	0.69	5400
Cokes	224E	14:00		0.7	91.0	8.3	0.58	
	221E	16:30		1.3	90.5	8.2	0.59	
	223E	20:30		1.6	90.3	8.1	0.59	
	232E	23:00		1.6	90.5	7.9	0.59	
			55% West Virginia Eagle 5% Illinois No. 5 40% Pocahontas					
Coal blend			1.5	25.1	69.1	5.8	0.73	498
Cokes	245E	14:00		0.6	92.0	7.4	0.61	
	243E	16:30		1.2	91.4	7.4	0.62	
	246E	18:40		1.1	91.4	7.5	0.61	
	247E	24:00		1.3	90.9	7.8	0.51	

Table B. - Coking Results for Blend of 75% Illinois No. 5 and 25% Pocahontas, at normal heating

	Run 210E	Run 215E	Run 206E	Run 219E	Run 207E
Coking time (Hr.:min.)	14:00	15:10	17:00	18:20	21:00
Coke Physical Properties					
Tumbler test					
Stability	52.0	56.1	56.7	57.1	58.4
Hardness	67.2	66.0	65.5	65.0	64.4
Shatter test					
+2"	73.8	75.8	83.3	81.3	87.5
+1½"	89.9	91.7	93.5	93.7	94.5
+1"	96.3	96.8	97.3	97.4	97.2
Coke sizing					
+4"	2.2	4.5	5.3	9.5	15.3
4" x 3"	17.0	18.7	21.9	27.2	29.5
3" x 2"	44.5	47.3	46.2	40.2	34.3
2" x 1"	30.1	22.9	19.5	15.1	12.9
1" x ½"	1.7	2.3	2.6	2.4	2.5
½"	4.5	4.3	4.5	5.6	5.5
Average size (in.)	2.28	2.41	2.48	2.64	2.80
Apparent gravity	0.82	0.81	0.81	0.81	0.81
Coke Yields (at 3% moisture) (% of coal as received)					
Total coke	70.5	70.0	71.0	70.2	70.6
Furnace (+1")	66.1	65.4	66.0	64.6	65.0
Nut and pea (1" x ½")	1.2	1.6	1.8	1.6	1.7
Breeze (-½")	3.2	3.0	3.2	4.0	3.9
Operating Data					
Pulverization (-1/8")	81.3	80.4	84.5	82.9	83.2
Flue temperature (°F.)					
Initial	1750	1675	1600	1525	1450
Maximum	2050	1975	1900	1825	1750
Coke temperature (°F.)					
Center of charge	1860	1815	1760	1705	1640

Table C. - Coking Results for Blend of 75% Illinois No. 5 and 25% Pocahontas, at fast initial heating

	Run 213E	Run 220E and 230E	Run 208E	Run 216E	Run 214E
Coking time (Hr.:min.)	12:00	13:30	15:20	16:30	18:30
Coke Physical Properties					
Tumbler test					
Stability	49.0	50.1	53.7	54.8	56.4
Hardness	66.8	67.1	66.4	65.9	64.1
Shatter test					
+2"	67.7	73.1	78.4	80.1	85.0
+1½"	88.1	89.5	90.3	93.5	94.9
+1"	96.1	96.2	96.5	97.2	97.2
Coke sizing					
+4"	2.9	3.2	5.0	8.9	11.2
4" x 3"	12.5	18.1	17.3	28.3	27.2
3" x 2"	40.4	41.8	42.9	36.5	38.6
2" x 1"	35.9	30.6	28.0	19.8	15.8
1" x ½"	3.6	2.0	2.6	2.0	2.1
-½"	4.7	4.3	4.2	4.5	5.1
Average size (in.)	2.15	2.31	2.35	2.63	2.69
Apparent gravity	0.80	0.80	0.82	0.80	0.81
Coke Yields (at 3% moisture) (% of coal as received)					
Total coke	70.7	70.4	70.1	70.0	70.0
Furnace (+1")	64.8	65.7	65.3	65.5	65.0
Nut and pea (1" x ½")	2.5	1.6	1.8	1.3	1.4
Breeze (-½")	3.4	3.1	3.0	3.2	3.6
Operating Data					
Pulverization (-1/8")	81.7	80.0	82.0	84.1	80.0
Flue temperature (°F.)					
Initial	1900	1825	1750	1675	1600
Maximum	2050	1975	1900	1825	1750
Coke temperature (°F.)					
Center of charge	1860	1815	1760	1705	1640

Table D. - Coking Results for Blend of
50% Illinois No. 5 and
50% Virginia medium-volatile

	Run 276E	Run 274E	Run 275E	Run 273E
Coking time (Hr.:min.)	14:00	16:30	19:15	24:30
	Coke Physical Properties			
Tumbler test				
Stability	55.7	61.7	64.1	65.4
Hardness	70.2	70.2	70.1	68.9
Shatter test				
+2"	71.2	78.1	83.1	91.3
+1½"	90.5	93.5	95.0	96.5
+1"	97.2	97.3	97.4	98.3
Coke sizing				
+4"	2.0	3.9	8.7	17.1
4" x 3"	13.3	21.0	27.9	31.2
3" x 2"	48.9	51.5	43.9	37.8
2" x 1"	29.5	18.3	14.7	9.0
1" x ½"	2.4	1.6	1.7	1.5
-½"	4.9	3.7	3.1	3.4
Average size (in.)	2.25	2.49	2.71	2.96
Apparent gravity	0.89	0.88	0.88	0.85
	Coke Yields (at 3% moisture) (% of coal as received)			
Total coke	74.9	74.6	74.4	74.7
Furnace (+1")	70.3	70.7	70.9	71.1
Nut and pea (1" x ½")	1.7	1.2	1.2	1.1
Breeze (-½")	2.9	2.7	2.3	2.5
	Operating Data			
Pulverization (-1/8")	89.6	88.1	87.5	89.4
Flue temperature (°F.)				
Initial	1750	1600	1500	1450
Maximum	2050	1900	1800	1750
Coke temperature (°F.)				
Center of charge	1879	1745	1657	1618

Table E. - Coking Results for Blend of
50% Illinois No. 6 and
50% Virginia medium-volatile

	Run 270E	Run 271E	Run 269E	Run 268E
Coking time (Hr.:min.)	14:00	16:30	19:10	24:30
	Coke Physical Properties			
Tumbler test				
Stability	55.2	62.6	62.7	64.7
Hardness	71.6	70.3	69.2	68.6
Shatter test				
+2"	74.0	82.9	89.1	92.3
+1½"	90.0	93.5	95.9	96.5
+1"	96.5	97.4	97.9	97.8
Coke sizing				
+4"	3.9	3.3	8.1	31.9
4" x 3"	15.8	21.9	31.2	35.0
3" x 2"	43.9	47.0	39.2	21.8
2" x 1"	31.7	22.0	16.1	5.4
1" x ½"	1.3	2.0	1.5	1.6
-½"	3.4	3.8	3.9	4.3
Average size (in.)	2.32	2.44	2.70	3.31
Apparent gravity	0.86	0.85	0.84	0.84
	Coke Yields (at 3% moisture) (% of coal as received)			
Total coke	72.7	73.1	73.8	74.1
Furnace (+1")	69.3	68.9	69.9	69.8
Nut and pea (1" x ½")	1.1	1.4	1.1	1.2
Breeze (-½")	2.4	2.8	2.8	3.1
	Operating Data			
Pulverization (-1/8")	86.1	86.1	86.6	86.9
Flue temperature (°F.)				
Initial	1750	1600	1500	1450
Maximum	2050	1900	1800	1750
Coke temperature (°F.)				
Center of charge	1870	1752	1670	1622

Table F. - Coking Results for Blend of 65% Kentucky Elkhorn and 35% Pocahontas

	Run 257E	Run 256E	Run 258E	Run 255E	Run 254E
Coking time (Hr.:min.)	14:00	16:30	18:20	24:30	28:00
Coke Physical Properties					
Tumbler test					
Stability	51.6	56.1	58.6	58.0	62.1
Hardness	69.5	68.5	68.2	62.1	65.9
Shatter test					
+2"	64.9	76.0	81.3	91.9	94.3
+1½"	86.2	92.3	93.4	95.5	96.5
+1"	96.6	97.2	97.2	96.5	97.7
Coke sizing					
+4"	0.0	5.9	12.4	26.8	34.8
4" x 3"	12.3	26.2	24.0	28.7	25.4
3" x 2"	36.2	36.8	34.6	26.2	21.1
2" x 1"	44.0	23.6	20.5	8.8	9.4
1" x ½"	2.9	1.9	1.9	1.6	1.8
-½"	4.6	5.6	6.6	7.9	7.5
Average size (in.)	2.03	2.48	2.60	3.03	3.21
Apparent gravity	0.87	0.86	0.87	0.88	0.88
Coke Yields (at 3% moisture) (% of coal as received)					
Total coke	73.1	74.1	72.5	73.3	73.2
Furnace (+1")	67.6	68.5	66.4	66.4	66.4
Nut and pea (1" x ½")	2.1	1.4	1.3	1.2	1.3
Breeze (-½")	3.4	4.2	4.8	5.7	5.5
Operating Data					
Pulverization (-1/8")	82.7	83.3	85.8	83.9	84.7
Flue temperature (°F.)					
Initial	1750	1600	1500	1450	1450
Maximum	2050	1900	1800	1750	1750
Coke temperature (°F.)					
Center of charge	1831	1748	1683	1608	1615

Table G. - Coking Results for Blend of
75% West Virginia Eagle
25% Pocahontas

	Run 224E	Run 221E	Run 223E	Run 232E
Coking time (Hr.:min.)	14:00	16:30	20:30	23:00
	Coke Physical Properties			
Tumbler test				
Stability	59.0	58.3	59.4	59.5
Hardness	68.4	64.5	63.3	64.2
Shatter test				
+2"	79.5	85.2	89.5	90.5
+1½"	93.3	94.3	96.2	96.2
+1"	97.3	97.7	97.8	97.8
Coke sizing				
+4"	6.4	8.9	20.6	24.5
4" x 3"	26.2	28.7	31.9	40.8
3" x 2"	46.0	45.3	32.9	21.7
2" x 1"	16.2	12.0	9.5	7.6
1" x ½"	1.5	1.8	1.6	1.4
-½"	3.7	3.3	3.5	4.0
Average size (in.)	2.62	2.74	3.03	3.21
Apparent gravity	0.89	0.87	0.89	0.91
	Coke Yields (at 3% moisture) (% of coal as received)			
Total coke	75.0	74.0	74.1	76.0
Furnace (+1")	71.1	70.2	70.3	71.8
Nut and pea (1" x ½")	1.1	1.3	1.2	1.1
Breeze (-½")	2.8	2.5	2.6	3.1
	Operating Data			
Pulverization	89.2	89.8	88.3	89.5
Flue temperature (^{o}F.)				
Initial	1750	1600	1450	1450
Maximum	2050	1900	1750	1750
Coke temperature (^{o}F.)				
Center of charge	1849	1730	1609	1606

Table H. - Coking Results for Blend of
55% West Virginia Eagle
5% Illinois No. 5 and
40% Pocahontas

	Run 245E	Run 243E	Run 246E	Run 247E
Coking time (Hr.:min.)	14:00	16:30	18:40	24:00
	Coke Physical Properties			
Tumbler test				
Stability	58.4	61.2	63.2	61.1
Hardness	68.5	66.2	68.2	64.1
Shatter test				
+2"	75.2	87.2	90.4	94.8
+1½"	92.7	95.8	96.2	97.0
+1"	97.3	97.9	98.0	98.0
Coke sizing				
+4"	3.1	8.1	13.4	33.4
4" x 3"	14.2	25.5	34.0	31.4
3" x 2"	52.7	48.0	36.6	23.6
2" x 1"	24.5	13.4	10.2	5.5
1" x ½"	1.9	1.7	1.5	1.6
-1"	3.6	3.3	4.3	4.5
Average size (in.)	2.34	2.68	2.88	3.30
Apparent gravity	0.91	0.90	0.89	0.90
	Coke Yields (at 3% moisture) (% of coal as received)			
Total coke	79.9	78.3	79.6	81.0
Furnace (+1")	75.5	74.3	75.0	75.8
Nut and pea (1" x ½")	1.5	1.3	1.2	1.3
Breeze (-½")	2.9	2.7	3.4	3.7
	Operating Data			
Pulverization (-1/8")	91.4	90.8	92.2	92.5
Flue temperature (°F.)				
Initial	1750	1600	1500	1450
Maximum	2050	1900	1800	1750
Coke temperature (°F.)				
Center of charge	1879	1730	1685	1645

Illinois State Geological Survey Circular 246
26 p., 16 figs., 3 tables, app., 1958

CIRCULAR 246

ILLINOIS STATE GEOLOGICAL SURVEY

URBANA

114